

XII.—*On Hermaphroditism and Vestigial Structures in the Reproductive Organs of Testudo græca.* By H. B. FANTHAM, B.Sc. Lond., A.R.C.S., University College, London.

[Plate VI.]

AMONG the various groups of the Vertebrata from time to time there occur cases of true hermaphroditism, or of the persistence of some of the genital organs of the opposite sex, especially in the male. Such occurrences are of interest, and as apparently few (if, indeed, any) instances have hitherto been described among the Chelonia, I considered the following two cases, which recently came under my notice, worthy of record.

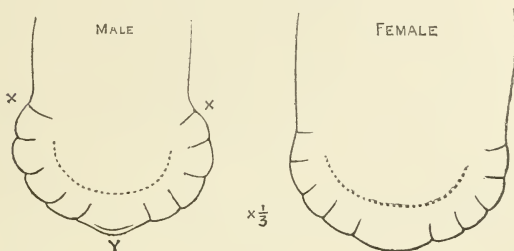
Last summer, while dissecting a specimen of *Testudo græca*, an abnormal development of the genitalia was noticed. Further examination showed that the specimen in question was hermaphrodite, after comparison with male and female specimens of this tortoise procured and dissected. Since that date other adult specimens of *Testudo græca* have been examined, about a dozen altogether, of which all but two possessed the external characters of the male. Among those with male external features was one showing the persistence of the Müllerian ducts as slender rudimentary tubes. To distinguish between these two tortoises, each with abnormal reproductive organs, the hermaphrodite specimen first found may be denoted by A, and the second one (a male with vestigial oviducts) by B. The anatomy and histology of each may then be dealt with, as far as possible.

I. *External Characters and Anatomy.*

The external features aiding in the determination of the sex of a tortoise are, according to Gadow [4], as follows:—The male is slightly smaller in size, has a long tail, and possesses a concave plastron. The plastron of the female is flat. Another point of difference between the sexes that I noticed was in the shape of the posterior end of the plastron, as viewed ventrally (see text-figures).

Concerning the anatomy of the tortoise, no easily accessible detailed account in English is known to me. I have used Bojanus's figures and explanations of *Emys europæa* [2]. In Sedgwick's recently published "Vertebrata" [10] of his 'Student's Text-book of Zoology,' however, a good general account of the anatomy of the Chelonia is given.

At first it does not appear easy to delineate the relation of the gonad and the kidney in *Testudo*. The latter organ (kidney) is very dorsal and posterior in position and needs careful dissection, being covered ventrally by a black pigmented body. This is the epididymis, lying naturally on



A marked indentation or angle at \times in the case of the exoskeleton of the male. The female is more rounded than the male, especially at Y.
 \times .

the top of the kidney, from the ventral aspect, in a closely ensheathing and darkly pigmented mesentery (*cf.* Pl. VI. fig. 2, *ep.*). In this mesentery vasa efferentia pass from the testis, and by it the testes are attached to the kidneys. The testes (fig. 2, *t.*) are normally brownish-yellow bodies, ovoid in shape, about 1.6 to 1.8 cm. long, 1.2 to 1.3 cm. broad, and 1 cm. thick. The kidneys (fig. 2, *k.*) are dark brown, showing a convoluted ventral surface. There is a slight orange supra-renal body on the ventral or inner surface of each kidney, partly covered in the natural position by the epididymis and testis. The supra-renal body of each side is apparently the "*Ren succenturiatus*" of Bojanus in his figures of *Emys europæa*.

Tortoise A.—This specimen in external features possessed a slightly concave plastron (rather less concave than in the normal male), had a long tail, and was a little smaller in size than the female specimens compared (though, of course, this may be merely a question of age). It had well developed gonads—the left one of which, at any rate, might be termed an "ovotestis" (see below)—and well developed oviducts (Müllerian ducts), in addition to well-marked epididymes, vasa deferentia, and penis, which are, of course, essentially male genitalia. The epididymes of this specimen were slightly larger than in some of the normal males examined. The gonads (Pl. VI.

fig. 1, *g.*) attracted attention as soon as seen, being yellowish brown in colour, rather elongate ovoid in shape, and slightly larger, darker, and more pointed anteriorly than the testes in normal male specimens. The gonads were approximately equal in size and general shape, about 1.9 cm. long, 1.1 cm. broad, and 1 cm. thick. Especially noteworthy was the presence of a conspicuous yellow egg (fig. 1, *o.*) on the ventral surface of the posterior third of the left gonad (hence use of term "ovotestis" for this gonad). This egg was .3 cm. in diameter, but those found in females of *T. graeca* were often larger.

The Müllerian ducts were well developed and lay ventral and to the outer side of each gonad (fig. 1, *m.*). They were light yellow in colour and approximately equal in length, and their external diameter varied from .3 cm. anteriorly to .6 cm. in the uterine portion. They were attached by a mesentery posteriorly to the epididymis of either side, and anteriorly by the broad ligament to the lungs. Each opened in front by an ostium, apparently ciliated (fig. 1, *FL.*), into the coelom, considerably in front of the gonads. No eggs, however, were noticed free in the body-cavity, nor in the Müllerian ducts, the lumen of each of the latter being continuous throughout. These oviducts opened into the neck of the cloacal bladder, slightly behind and ventral to the ureters and vasa deferentia, as shown in Pl. VI. fig. 1. The foldings of these ducts were chiefly confined to their anterior third.

Tortoise B.—This specimen exhibited all the external characters of the male, the concavity of its plastron being well marked. The genitalia (Pl. VI. fig. 2) were of the normal size, shape, and appearance common to the male tortoise, each testis being 1.6 cm. long, 1.2 cm. broad, and 1 cm. thick. But in addition there were rudimentary Müllerian ducts present (fig. 2, *m.*), opening anteriorly into the coelom, that of the left side being slightly longer than that of the right, but rather narrower in its posterior sixth and at its entrance to the cloaca (Pl. VI. fig. 2). The hinder portion of the right oviduct being wider (.3 cm. in external diameter), its posterior fifth was found to contain functionally mature spermatozoa, which, however, were not found in the more constricted hinder part of the left oviduct. Apparently the basal part of the right rudimentary oviduct functioned as a sort of vesicula seminalis (*cf.* Howes's observations [6] on a specimen of *Lacerta viridis*), the spermatozoa having probably migrated into it from the vas deferens. Unfortunately the oviducts of specimen A were not examined for spermatozoa when fresh, for reasons given below.

II. *Histology.*

Tortoise A.—Sections of each of the gonads of this specimen were prepared and examined. Unfortunately the material was not fixed immediately after death, the alimentary canal and vascular system overlying the genitalia ventrally having been first dissected and examined in detail. On microscopic examination of the sections the material showed somewhat poor fixation, as was to be expected under the circumstances. Delafield's hæmatoxylin or iron-hæmatoxylin was used for staining, together with eosin or acid fuchsin. A few transverse sections of a portion across the end of the anterior third of the right gonad were made, and longitudinal sections of the whole of the rest of this gonad were cut. Testicular seminiferous canals and developing spermatozoa were seen in all the sections, but no developing ova could be made out with certainty. In longitudinal section the tissue was seen to be denser in the anterior part of this right gonad than in the posterior portion.

The left gonad was carefully sectionized longitudinally, as it showed on its ventral surface an apparent egg. This latter was, in section, found to be an ovum, the nucleus and yolk being seen (Pl. VI. fig. 3, *n.* & *y.*). Slightly anterior and dorsal to this ovum, and so within the substance of the left gonad, another was found developing, after examining a series of sections. Further, a few groups of bodies resembling developing "ovarian ova" were seen scattered in separate groups (follicles) among otherwise testicular tissue, more especially near the periphery of the anterior portion of the gonad (Pl. VI. fig. 4, *ov.*). The rest of this organ consisted of seminiferous canals, connective-tissue stroma, and a few blood-vessels. I very much regret that circumstances do not permit of my giving a longer and more detailed account of the histology of the left gonad, owing to unavoidable delay in fixation.

The oviducts were lined internally by a glandular epithelium, as is normally the case in the female, the walls being highly muscular.

Tortoise B.—The right gonad was carefully fixed in corrosive sublimate and acetic acid, and sectionized. The left gonad was teased up. In neither case were any traces of ova found, only seminiferous canals and developing spermatozoa. The fact of mature spermatozoa being found in the right rudimentary oviduct directly after death has been already mentioned. These oviducts, the lumen of each of which was in some parts very narrow but continuous, were lined by a glandular epithelium, though the walls were thin.

Tortoise A, according to the classification of Taruffi (quoted by Windle [14]), would be a bilateral hermaphrodite. Tortoise B would perhaps be regarded by him as pseudo-hermaphrodite. However, specimen B was without doubt functionally a male, while A had a preponderance of male characters.

III. Note on Hermaphroditism in the Vertebrata.

It may at once be said that this is rare, especially in the Amniota. It occurs in *Myxine*, which is protandrous. It occurs casually in some Selachians and in the Sturgeon. Among Teleostean fishes it constantly occurs in *Serranus* and *Chrysophrys*, while it is occasionally met with in the cod, herring, mackerel, &c.

Among the Amphibia it is known in *Triton* (*Molge*) *taeniatus* and some frogs. There is the remarkable "Bidder's organ" in toads. Among frogs the possession of well-marked rudiments of Müllerian ducts is fairly common, while specimens with complete Müllerian ducts or oviducts are sometimes found together with hermaphrodite gonads (cf. Marshall [9] and others). Remains of Müllerian ducts may occur in *Emys europæa*, *Lacerta viridis* (cf. Howes [6]), and *L. agilis* (cf. Jaquet [8]) among Reptiles, and hermaphroditism has been recorded in the chaffinch among birds.

A remarkable case of hermaphroditism in the common fowl was, I believe, lately exhibited at the Royal Society's *Conversazione*, showing secondary characters of both sexes in addition to a strictly hermaphrodite gonad.

Professor Howes in 1891 described a case of hermaphroditism in the codfish [7], and, after discussing the significance of the phenomenon in the Vertebrates, inclined to the idea that the ancestral vertebrate was hermaphrodite. Whether this is likely or not is open to question. The case of *Myxine* is usually considered as a secondary acquirement of hermaphroditism, connected with its partially parasitic habit. The young tadpole of the frog is at one period of its existence indifferent, which should be carefully distinguished from hermaphrodite.

If hermaphroditism be considered the primitive or ancestral condition of the Vertebrata, then the cases of tortoises A and B are retrogressive. Stephan [11], in an exhaustive and valuable paper on this question, inclines to the view that hermaphroditism in the Vertebrates is not a phenomenon of retrogression, but a secondary acquirement, substituted for the dicecious state (Stephan, 1902, page 129).

Again, the female organ (ovary) is perhaps simpler and more primitive than the male organ (testis), as suggested by Marshall [9], the ovum being undoubtedly less highly differentiated than the spermatozoon. A long theoretical discussion on the question of hermaphroditism in the Vertebrates would, however, be out of place in this paper.

In the foregoing note only the more commonly occurring and well known forms of Vertebrates in which hermaphroditism may be found are mentioned. A very full bibliography and comprehensive treatment of the subject will be found in Stephan's paper of 1902. A few other papers, relating especially to the Reptilia, will be cited in the appended references.

In the present state of our knowledge only suggestions as to the significance of hermaphroditism in forms like the tortoise can be put forward, and the recording of such occurrences may be of value in developing that knowledge.

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EXPLANATION OF PLATE VI.

<i>b.v.</i> Blood-vessel.	<i>ov.</i> Ovarian ovum in follicle.
<i>cl.</i> Cloaca.	<i>p.</i> Penis.
<i>ep.</i> Epididymis.	<i>r.</i> Rectum.
<i>f.ep.</i> Follicular epithelium.	<i>t.</i> Testis.
<i>Fl.</i> Cœlomic aperture in Müllerian duct.	<i>ts.</i> Seminiferous tubules.
<i>g.</i> Gonad.	<i>v.ef.</i> Vasa efferentia.
<i>k.</i> Kidney.	♂. Aperture of vas deferens contiguous with that of ureter.
<i>m.</i> Müllerian duct (oviduct)	♀. Aperture of Müllerian duct.
<i>n.</i> Nucleus.	<i>y.</i> Yolk.
<i>o.</i> Ovum.	

- Fig. 1.* *Tortoise A*, genitalia seen from ventral surface. Cloacal bladder removed ventrally. Left Müllerian duct and epididymis separated and slightly displaced to show kidney dorsal to them. Penis turned over dorsally to show groove. Nat. size.
- Fig. 2.* *Tortoise B*, genitalia, ventral view. Round and broad ligaments not shown (nor in fig. 1). Cloacal bladder cut away ventrally. Nat. size.
- Fig. 3.* Part of a longitudinal section of the left gonad of *Tortoise A*, showing an egg on the surface and the relative size of the seminiferous tubules of the rest of the gonad. $\times 12$ diameters.
- Fig. 4.* Part of a longitudinal section of the left gonad of *Tortoise A*, showing developing follicle (with ovarian ovum) wedged in between seminiferous tubules. Slightly diagrammatic. $\times 100$ diameters.

XIII.—*Reply to Mr. G. A. Boulenger.* By NILS ROSÉN.

To the "Remarks" which Mr. Boulenger in the March number of these 'Annals' has made upon my paper on snakes belonging to the Museums of Lund and Malmö, and which at first sight may seem to many to have been totally annihilating, I beg to give the following reply, which I hope will fully convince all impartial readers of the groundlessness of these "Remarks."

I will begin with Mr. Boulenger's statement that the snake I have described as a new genus under the name of *Anisodon Lilljeborgi* is identical with *Psammodynastes pulverulentus*, Boie, and first make a comparative survey of the most prominent differences between them:—